24 FEB 1948

UNIVERSITY OF VERMONT
AND STATE AGRICULTURAL COLLEGE

AMANI

VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

BULLETIN NO. 153

MAY, 1910

Plant Diseases; Potato Spraying.

I. Plant Diseases of 1909—Pages 620-622.
II. Potato Spraying Experiments of 1909—Pages 622-629.

BURLINGTON:
Free Press Printing Company,
1910.

BOARD OF CONTROL

PRES. M. H. BUCKHAM, *ex-officio*, Burlington.
HON. E. J. ORMSBEE, Brandon.
HON. CASSIUS PECK, Burlington.
HON. G. S. FASSETT, Enosburgh.

OFFICERS OF THE STATION

J. L. HILLS, Director.
F. A. RICH, Veterinarian.
CASSIUS PECK, Farm Superintendent.
C. H. JONES, Chemist.
R. M. WASHBURN, Dairy Husbandman.
A. F. HAWES, (State Forester), Forester.
H. A. EDSON, Bacteriologist.
M. B. CUMMINGS, Horticulturist.
P. A. BENEDICT, Assistant Chemist.
JENNIE L. ROWELL, Assistant Chemist.
J. W. WELLINGTON, Assistant Horticulturist.
W. F. HAMMOND, Expert in Horse Breeding.*
STANLEY HARGREAVES, Gardener.
MARY E. PATTRIDGE, Stenographer.
INA RAND, Stenographer.
C. P. SMITH, Treasurer.

☞Copies of the reports and bulletins of the Station are sent free of charge to any address upon application.

☞Address all communications, not to individual officers, but to the Experiment Station, Burlington, Vt.

Director's and State Forester's offices, chemical, horticultural and dairy laboratories are in Morrill Hall at the head of Main street; botanical and bacteriological laboratories are at Williams Science Hall, University Place; veterinary laboratories at 499 Main Street.

Experiment farm and buildings are on the Williston road, adjoining the University grounds on the east.

---

*In cooperation with Bu. An. Ind. U. S. Dept. Agr.

P.A.B
MAR 1948

BULLETIN 153: PLANT DISEASES; POTATO SPRAYING

B. F. LUTMAN[1]

SUMMARY

I. Plant Diseases of 1909.

The season was a rather dry one and the plant diseases reported were largely of a physiological nature. Many of the more common diseases due to fungi were observed, but there were no serious outbreaks. Stem and leaf blight of oats and barley seemed to be the most frequently noted. Pages 620-622.

II. Potato Spraying Experiments of 1909.

The spraying experiments were conducted with the view of determining what constituent of the bordeaux mixture causes the increased yield from sprayed plots. It was found by spraying plots with solutions of iron sulphate and of lime that neither iron nor lime would cause this effect. It would seem, therefore, that this constituent must be the copper. The plants, however, were not able to take up enough of the copper from the bordeaux mixture, when it is applied to their roots and not to their foliage, to produce the same effects. The increased yield from plots sprayed, either with bordeaux mixture or with bordeaux mixture made up with part of the copper sulphate replaced by iron sulphate, was more than sufficient to pay all the expenses of spraying. Pages 622-629.

---

[1]The author is indebted to Professors L. R. Jones and H. A. Edson, and to Mr. C. M. Gifford for assistance in various ways.

I. PLANT DISEASES OF 1909

Owing to the fact that the season of 1909 was a rather dry one with no long continued rainy weather, many of the fungus diseases that are dependent on such conditions for their spread did not appear. The downy mildew was observed on the cultivated grape at Burlington, and, while reports of many of the commoner diseases, such as pear blight, point rot of the tomato, bean anthracnose, scabbiness of beets and potatoes, were received, there were no serious outbreaks.

LEAF BLIGHT ON BARLEY AND OATS

Only one disease of the cereal crops seemed to be so common as to elicit many inquiries from the Station. This was characterized by the dying of the lower leaves of the oat and barley during their growing season. This malady has been generally assumed until recently to be due to physiological disturbances, but Manns[1] describes what is undoubtedly the same disease, apparently bacterial in its nature. These bacteria are carried up and down the stalk and leaves of the oat or barley plant and to other plants by the plant lice (aphids) which are nearly always abundant on the various grains. By these insects the disease is spread over the same plant and throughout a field.

PHYSIOLOGICAL DISEASES

The dryness of the season caused a number of the physiological diseases such as usually appear in such weather. Some of the reported maladies, especially of the red maple, were due not so much to the dry weather of this season as to the weakened condition resulting from the very dry weather of two summers ago. These diseases are usually caused by a lack of water at critical times in the growth of the plants. The tip-burn of potatoes, the dying of the leaves of apple, maple and horsechestnut trees were among those reported.

---

[1]Ohio Sta. Bul. 210 (1909).

LATE BLIGHT OF POTATO

As noted last year[1] this disease was only occasional in Vermont in 1907 and was not reported at all in 1908, owing undoubtedly to the unusually dry weather of that year. Potatoes were sent us in 1909 from Dover, Windham county, affected by the dry rot resulting from late blight (*Phytophthora infestans*).

BLACKLEG OF THE POTATO

Blackleg of the potato occurred occasionally in the experimental fields, but has not been elsewhere reported, perhaps because many farmers do not recognize it. The malady is characterized by a rotting and blackening of the potato stem just below the surface of the ground, resulting in a small and sickly top. As has been shown by Morse[2] and by Smith[3] of the United States Department of Agriculture the disease is due to bacteria.[4]

A NEW POTATO DISEASE

One of the potato diseases that has not as yet been reported to the Station, but for which a close lookout should be kept by Vermont growers, especially by those who import potatoes for seed, is that which has been described by the botanist of the Canadian Station at Ottawa.[5] This disease is caused by a fungus (*Chrysophylictis endobiotica*) and is characterized by a swelling and distortion of the tubers, making them entirely unsalable. It seems to be one of the most dangerous potato diseases of recent introduction and should be suppressed as soon as it appears. Growers fearing that they have the disease in their stock should send samples of the suspected tubers to the Station for examination. Such infections are easily controlled in their beginnings, but the disease is almost impossible to eradicate after

[1]Vt. Sta. Bul. 142 (1909).
[2]Maine Sta. Bul. 174 (1909).
[3]Science, May 13, 1901, pp. 748-749.
[4]See also in this connection Vt. Sta. Rpt. 19, pp. 217-265 (1906); 20, p. 330 (1907).
[5]Cent. Exp. Farm, Ottawa, Canada, Bul. 63 (1909).

it has obtained a foothold. A recent circular of the United States Department of Agriculture[1] describes this disease, under the title "Wart Diseases of the Potato; a dangerous European disease liable to be introduced into the United States."

II. POTATO SPRAYING EXPERIMENTS OF 1909

The experience gained at this Station in potato spraying work of the past 18 years amply proves that the application of bordeaux mixture to the foliage always augments the yield of tubers. While greatest of course in those years when either the late or the early blight is present and attacks those plants that have not been sprayed, this increase occurs in seasons when little or no fungus disease is present to reduce the yield upon the unsprayed control plots. The bordeaux mixture seems to serve a double purpose when used on the potato crop:—it prevents the attack of fungi and it serves as a stimulant to the plant. It would seem that the eighteen years of spraying experience detailed on page 628 is ample proof of its ability to ward off fungus attack. Incidentally the second point has also been proved, or rather, the second idea has developed from the trials made of bordeaux mixture as a fungicide. While it is not possible to determine accurately the extent of this increase due to the spraying itself, apart from any fungicidal effect, it would seem (judging from years when little disease was present) to amount to 30 to 70 bushels per acre, which, at ordinary sale prices, would more than pay the cost of application, even were there no protection afforded against disease. The potato spraying experiments of this year were directed particularly at the determination of this matter of stimulation of the plants by the bordeaux.

Results pointing affirmatively in this direction have been obtained by other stations in this country, notably at the New York (State) station, where experimental potato spraying has been carried on for a number of years. The results obtained at German stations have not been consistent. Bordeaux spraying

[1]U. S. Dept. Agr., Bu. Pl. Ind., Bul. 52 (1910).

causes the plant to take on a darker green color and to thicken its leaves. It is claimed by some investigators that this darker color is due to a partial shading of the plant where the bordeaux adheres to the leaves. Others believe that it is slightly absorbed by the leaves and produces some sort of a toxic effect on the leaf cells, and that, as a result of this poisoning, the leaf cells become expanded (hypertrophy) and are so injured that they are unable to secrete the diastase which normally is employed in the removal of the starch formed therein to other parts of the plant. While some German investigators claim that spraying with bordeaux increases the yield over and above its effect as a fungicide, most of the more recent work carried out in that country seems to show that spraying is not beneficial in this respect, that is to say in the matter of plant stimulation, and to indicate that the weaker the bordeaux mixture and the less the number of times it has to be applied, the better it is for the plants. It is not to be inferred, however, that this view is universally held.

Observations hitherto made at this station have confirmed those reported by the German investigators and by Harrison[1] that plants which have been sprayed with bordeaux display foliage with thicker leaves and of a darker green than do those that have not been so treated. Tip-burn is also much less in evidence on the sprayed as compared with the unsprayed plants. This fact is of special importance when we remember that the potato tubers increase in size and in starch content during the months of August and September when the tip-burn is especially prevalent.[2] The tip-burn, of course, lessens the assimilation surface of the leaves and in the same measure diminishes the amount of starch which may be produced.

There seems to be no doubt whatever that under our climatic conditions an increase in the yield occurs over and above that caused by fungicidal effects. And, as heretofore remarked, it was with the view of discovering, if possible, the chemical

[1]Ontario Agl. Coll. Sta. Rpt. 23 (1898).
[2]Vt. Sta. Rpt. 13, pp. 374-382 (1900).

constituents of the bordeaux mixture to which this stimulating effect is due, that the spraying experiments of 1909 were conducted.

For this purpose plots were sprayed as follows:

(1) Bordeaux mixture. Five pounds copper sulphate, 5 pounds lime, 50 gallons water.

(2) Bordeaux mixture, in which some of the copper sulphate had been replaced by iron sulphate; 2 pounds copper sulphate, 4 pounds iron sulphate, 6 pounds lime, 50 gallons of water.

(3) Iron sulphate with lime; 5 pounds of iron sulphate, 5 pounds lime, 50 gallons of water.

(4) Bordeaux mixture sprayed on the soil, using the same quantity as on the foliage, the same mixture being applied at the same time.

(5) Control plots, unsprayed but dusted with lime and paris green to kill the potato beetles.

Paris green was added to each of the above spray mixtures at the rate of 1 ounce to each 50 gallons.

The mixtures were applied at the rate of 250 gallons per acre.

Commercial copper sulphate (blue vitriol) is never free from iron sulphate, the amount present varying from 2 to 20 percent, 2 percent being allowed under the present standard. Some of the German investigators, who were unable to obtain increased yields from spraying with bordeaux mixture made from chemically pure copper sulphate, claim that the very favorable results obtained by others have been due to the exceedingly impure copper sulphate they used in preparing their bordeaux; that in other words the stimulating effect, with its resultant increased yield, is due to the iron sulphate present as an impurity in the copper sulphate, rather than to the copper sulphate itself. It was with the view of proving or disproving this contention that the trials were made on plots 2 and 3. If the application

of iron sulphate is a stimulus to starch production when it only forms a small percentage of the mixture, its addition in small quantities ought to produce the same results. The use on plot 3 of both iron and lime at the same time ought also to indicate whether the lime plays any part in this increased yield. And, finally, in order to determine whether the plant could absorb any of the constituents of the copper sulphate by way of the roots in sufficient quantity for it to have the same effect as if the mixture were applied to the leaves, the soil and the soil only was sprayed on plot 4 and the leaves kept spotlessly clean of bordeaux.

The season was a particularly favorable one for experimentation along these lines, as no disease, with the exception of tip-burn, appeared in the field. Insect injuries on the control plots were almost absolutely controlled, except for minor ones caused by the flea beetle.

Green Mountain potatoes were planted on a rather sandy soil on May 28, and were dug October 7. The plots were sprayed July 12, July 23, August 6 and August 27. The control plots were dusted thrice with lime and paris green. Examinations were made of the vines every two or three weeks from mid-July onwards and their condition noted. Tip-burn was prevalent by the middle of August. The plots that had been sprayed with the iron sulphate, those sprayed with bordeaux mixture on the soil, and the unsprayed control plots suffered the most, while those sprayed with bordeaux mixture on the foliage and those where iron sulphate had been added to the bordeaux were least affected. The death of the leaflets on the three first mentioned plots progressed during September and the plants were dead about two weeks before those sprayed with bordeaux or with bordeaux-iron sulphate mixture. The tubers were dug after the death of the plants on these latter two plots. There seemed to be but little difference in the thriftiness of the plants on these latter two plots, except that the foliage of those sprayed with bordeaux mixture were of a blue-green, while those sprayed with

the bordeaux-iron sulphate mixture showed more of a yellow-green tint. When 95 percent of the leaflets of the control plants were attacked by tip-burn, most of them badly, not over two-thirds of the plants sprayed with bordeaux mixture or bordeaux-iron sulphate mixture showed injury, and these but slightly.

When the plots were dug, Oct. 7, the total yields of potatoes, both large and small, calculated on the acre basis, were found to be:

	1 Bordeaux mixture	2 Bordeaux mixture plus iron sulphate	3 Iron sulphate plus lime	4 Bordeaux mixture on soil	5 Control
Bushels per acre,	243	235	168	190	188

While the percentage of starch varies in different varieties of tubers, and in the same variety at different times in the season, 20 percent of the weight of the tuber is about a fair average as expressive of the starch content. Using this figure as a basis the amounts of starch produced on the various plots were as follows:

	1	2	3	4	5
Pounds of starch per acre,	2,917	2,824	2,012	2,282	2,258

These figures, it will be noted, give the total amount of starch produced by the plants under the various treatments. The yields on plots 3, 4 and 5 were much the same, such slight differences as occurred being easily accounted for by possible soil variations. The yields on plots 1 and 2 were also practically the same, and were nearly one-third greater than were those obtained from the other three plots. The mixtures used on these two plots were the only ones containing copper; and it would seem to be a fair inference that the presence of the copper was the cause of the increased yield. Spraying with iron sulphate and lime caused no increase; nor were the plants able to absorb the copper in sufficient amounts from the soil (plot 4) to show any stimulating effects.

The only potatoes that have market value are those of marketable size. The yields obtained on the various plots separated into salable potatoes and small potatoes were:

MARKETABLE TUBERS

	1 Bordeaux mixture	2 Bordeaux mixture and iron sulphate	3 Iron sulphate and lime	4 Bordeaux mixture sprayed on soil	5 Control
Bushels per acre,	192	184	117	115	138
Pounds of starch per acre,	2,303	2,207	1,408	1,382	1,651

SMALL TUBERS

	1 Bordeaux mixture	2 Bordeaux mixture and iron sulphate	3 Iron sulphate and lime	4 Bordeaux mixture sprayed on soil	5 Control
Bushels per acre,	51	51	51	75	50
Pounds of starch per acre,	614	617	604	900	607[1]

The increase in the yields on plots 1 and 2 consisted of large marketable potatoes. The yields of small potatoes were about the same on all the plots, except that there was an unusually heavy production on that plot the soil of which received the bordeaux mixture spray. This may have been due in part to soil conditions. It hardly seems probable that the spraying of bordeaux mixture upon the soil was the cause of this increased yield of small tubers; but the occurrence is of sufficient interest to warrant careful observations in further trials.

In general it may be said that the results of spraying in 1909 have served to confirm those obtained in the previous years. Bordeaux mixture when applied to the potato foliage increases the starch yield to an extent sufficient to pay for all the expenses of application, not to speak of its beneficial fungicidal effect. It would seem, too, that the bordeaux mixture, in which part of

[1]Minor divergencies due to fractions.

the copper is replaced by iron, has practically the same effect. Whether such a mixture would be in addition as effective a fungicide against late and early blight as is the regular old-time standby, has not yet been determined. The fact, however, that these two mixtures were the only ones containing copper, and were the only ones causing increased yields, seems to show that the stimulating effect is due to the copper.

The following table summarizes the gains from the use of bordeaux mixture on late potatoes for the last 19 years at the Vermont station.

GAINS FROM THE USE OF BORDEAUX MIXTURE ON LATE POTATOES

Planted	Sprayed	Yield per acre		Gain per acre	
		Sprayed	Not sprayed		
White Star,		bu.	bu.	bu.	%
May —, 1891	Aug. 26, Sept. 8,	313	248	65	26
May 20, 1892	July 30, Aug. 13, 25,	291	99	192	194
May 20, 1893	Aug. 1, 16, 29,	338	114	224	196
Apr. 26, 1894	June 16, July 17, Aug. 30,	323	251	72	29
May 20, 1895	July 25, Aug. 13, 31,	389	219	170	78
Polaris,					
May 15, 1896	Aug. 7, 21,	325	267	68	26
June 1, 1897	July 27, Aug. 17, 28,	151	80	71	89
White Star,					
May 10, 1898	July 21, Aug. 10,	238	112	126	112
Average,					
3 varieties,					
May 18, 1899	July 26, Aug. 17, Sept. 8,	229	161	68	42
Delaware,					
May 23, 1900	Aug. 4, 23,	285	225	60	27
May 25, 1901	July 20, Aug. 21,	170	54	116	215
May 15, 1902	Aug. 1, 20,	298	164	134	82
Green Mountain,					
May 1, 1903	Aug. 10,	361	237	124	52
Delaware,					
May 25, 1904	Aug. 1, Sept. 1,	327	193	134	69
May 15, 1905	Aug. 2, 21,	382	221	161	73
Green Mountain,					
May 27, 1906	Aug. 13, 22,	133	101	32	32
May 1, 1907	July 16, 25, Aug. 8, 22,	171	63	108	175
May 15, 1908	June 26, July 9, Aug. 6, 26,	156	65	91	140
May 28, 1909	July 12, 23, Aug. 6, 27,	243	188	55	29
	Average of 19 years,	269	160	109	89

It is hardly necessary to comment further on these figures than to emphasize the following points:

The mixture consists of five pounds copper sulphate, five pounds lime, fifty gallons (one barrel) water, to which is added if needed a half pound paris green in order to combat the colorado beetle.

Spraying should begin while the plants are still healthy and vigorous.

Spraying should be thoroughly done, at least two barrels of the mixture per acre being applied.

If in doubt as to when to begin, start earlier and spray oftener than seems necessary, since an excess of the mixture does no harm.

Bulletin 113 (free for the asking) discusses spraying and gives directions for the preparation and use of many kinds of fungicides and insecticides.